Remarks

Claims 43, 56, 60, 96-99, 129, 130, 132-135, 148, 166, 167, 174, 185-188, 190, 191, 202 and 203 have been canceled. New Claims 206-235 have been added. Claims 41, 44, 57, 59, 61, 100, 101, 109, 110, 117, 126, 128, 131, 136, 141-143, 153, 154, 159, 165, 168-170, 173, 175-180, 183, 184, 189, 194, 196-201 and 205 have been amended. Claims 97, 98, 118, 119, 121-123, 133, 134, 144-148, 155-159, 175, 185-191 and 198-203 have been constructively withdrawn from consideration. Thus, Claims 41, 44, 46, 51, 53, 54, 57-59, 61-65, 100, 101, 103-119, 121-128, 131, 136-147, 149, 150, 152-165, 168-173, 175-184, 189, 192-197, 199-201 and 204-235 appear to be active in the present application. However, in view of the explanation of the constructively elected species in the Office Communication dated October 7, 2009, all of the pending claims, including new Claims 206-235, read on the elected species. No new matter is introduced by the present amendment.

A Declaration under 37 C.F.R. § 1.132 by Fabio Zurcher is submitted herewith, providing evidence of the superior solubility of silicon-containing semiconductor nanoparticles having a passivation layer covalently bound thereto selected from the group consisting of an alcohol, an alcoholate, a thiol, a thiolate, and an aralkyl group (see Claim 41 above) relative to hydrogen-passivated silicon nanoparticles or unpassivated silicon particles. In addition, the Zurcher Declaration provides evidence demonstrating unexpected and superior cyclosilane solubility, stability and UV polymerization properties in cycloalkanes (see Claim 207 above) relative to other solvents. The Zurcher Declaration also provides evidence that prior to the present application, it was not known whether compositions including passivated semiconductor nanoparticles, a cyclic Group IVA compound and a solvent could be formed with (i) sufficient mass loading of silicon-containing semiconductor nanoparticles, (ii) sufficient stability and solubility of the cyclic Group IVA compound(s), and (iii) suitable fluid mechanical properties for printing in a pattern having well-defined features which display controllable, reproducible morphology, such as one or more lines having dimensions as recited in Claim 211 above. As a result, the present claims are patentable over the cited references.

It is noted that a 3-month Suspension of Action request (with accompanying fee) was filed with Applicants' Request for Reconsideration on April 28, 2009. However, the present Office Action was issued on July 21, 2009, prior to the expiration of the 3-month Suspension of Action on July 28, 2009. A request for a refund of the 3-month Suspension of Action fee under 37 C.F.R. § 1.26(a) will be filed concurrently under separate cover.

In addition, on July 27, 2009, Applicants' representatives made a request for consideration of a Petition to Withdraw the Election of Species Requirement filed on July 31, 2008 (hereinafter, the "July 31, 2008 Petition"), and renewed their request for consideration of the July 31, 2008 Petition via telephone approximately weekly throughout August and September of 2009. Applicants' representatives received an Office Communication dated October 7, 2009 (hereinafter, the "October 7 Office Communication"), fourteen days before the expiration of the shortened statutory period for reply to the Office Action dated July 21, 2009 (hereinafter, the "July 21 Office Action"), that did not consider Applicants' Petition to Withdraw Election of Species Requirement filed on July 31, 2008.

Furthermore, each Office Action and/or Communication including and since the Office March 12 Office Action (in which a constructive election of species was made) has failed to provide any reason or explanation as to why the constructively elected species is patentably distinct from the constructively withdrawn species, instead merely restating that the species are patentably distinct (*vide infra*) or that they have "mutually exclusive characteristics." Accordingly, the Examiner has failed to provide plausible reasons and/or examples to support the conclusion that constructively elected species is patentably distinct from those species constructively withdrawn. As a result, the constructive election of species is improper. Applicants reaffirm their traversal of the constructive election of species in the March 12 Office Action, and ***Applicants respectfully request consideration of the July 31, 2008 Petition***.

The present invention relates to methods of making a patterned semiconductor film. In a first aspect, the method comprises:

a) printing a solution comprising silicon-containing semiconductor nanoparticles having a passivation layer covalently bound thereto selected from the group

consisting of an alcohol, an alcoholate, a thiol, a thiolate, an alkyl group, and an aralkyl group, a cyclic Group IVA compound of the formula (1):

$$(AH_x)_n, \qquad (1)$$

where n is from 3 to 8, each of the n instances of x is independently 1 or 2, and each A in the formula is independently Si or Ge, and a solvent in a pattern on a substrate; and

b) curing the printed pattern to form the patterned semiconductor film (see Claim 41 above).

In a second aspect, the present method comprises the steps of:

a) printing a solution comprising passivated semiconductor nanoparticles, the cyclic Group IVA compound of the formula (1) above, and a cycloalkane solvent in a pattern on a substrate; and

b) curing the printed pattern to form the patterned semiconductor film (see Claim 207 above).

In a third aspect, the present method comprises the steps of:

a) printing a solution comprising passivated semiconductor nanoparticles, a first cyclic Group IVA compound of the formula (1) above, and a solvent in a pattern on a substrate, wherein the pattern comprises one or more lines having a width of not more than 100 μm, a length of not more than 5000 μm, a thickness of not more than 1000 μm, and an inter-line spacing of not more than 100 μm; and

b) curing the printed pattern to form the patterned semiconductor film (see Claim 211 above).

The present claims advantageously provide methods for printing solutions comprising passivated semiconductor nanoparticles, a cyclic group IVA compound and a solvent in a pattern on a substrate, and subsequent curing thereof to form a patterned semiconductor film. Patterned semiconductor film structures made according to the presently claimed methods have improved physical and/or electrical properties (e.g., conductivity, density, adhesion and/or carrier

mobility), relative to structures made from nanoparticle inks without either passivated semiconductor nanoparticles or a cyclic group IVA compound (see paragraph [0006] of the present application). The presently claimed methods provide patterned semiconductor films of high quality, suitable for use in electronics applications, such as display devices or RFID tags, and can be formed by high-throughput printing processes.

The cited references Shiho, Jacobson '401, Piwcyzk (U.S. Pat. No. 4,022,928 [hereinafter, "Piwcyzk"]), Beppu et al. (U.S. Pat. No. 5,866,471 [hereinafter, "Beppu"]), Tani et al. (U.S. Pat. No. 5,254,439 [hereinafter, "Tani"]), Kim et al. (U.S. Pat. No. 6,355,198 [hereinafter, "Kim"]) and Korgel (U.S. Pat. App. Pub. No. 2003/0034486 [hereinafter, "Korgel"]) neither suggest nor render obvious, either alone or in combination, the methods of making patterned semiconductor films recited in the present Claims 41, 207 and 211. As a result, the present claims are patentable over the cited references.

The Objection to Claims 97, 126, 154, 159 and 201

The objection to Claims 97, 126, 154, 159 and 201 have been obviated by the present amendment. Claim 97 has been canceled. Claims 126 and 154 have been amended to provide proper antecedent basis. Claims 159 and 201 have been amended to recite "substantially soluble" in place of "high solubility."

Elections/Restrictions

The Examiner has required an election of species in the present application and appears to have constructively elected Species I from the following disclosed species:

Species I: for printing a composition and curing the composition;

Species II: where the passivation layer comprises an alcohol, a thiolate, an alkyl group, an aryl group, an aralkyl group, hydrogen, or a surfactant;

Species III: where the solvent is aprotic, apolar, or a gas-phase dipole; and

Species IV: with removing the solvent and cleaning with solvent (see page 2, lines 12-27 of the October 7 Office Communication).

Since all of the pending claims require printing a composition and curing the composition, all of the pending claims read on the constructively elected species. However, to the extent that the constructive election of species requirement is not moot in view of the Examiner's characterization of Species I, the requirement to elect a species in the present application remains largely unintelligible, and is unsupported by plausible reasons and/or examples. Thus, the election of species requirement and the constructive withdrawal of claims that the Examiner believes read on Species II-IV above is improper, and should be withdrawn.

First, the election of species requirement remains largely unintelligible. For example, in the October 7 Office Communication, the species appear to be characterized by claim number, in addition to subject matter to which the claim(s) are directed. It is noted that claims are definitions or descriptions of inventions; *claims themselves are never species*. M.P.E.P. §806.04(e); emphasis in original. *Species always refer to the different embodiments of the invention*. M.P.E.P. §806.04(e); emphasis in original. If the election of species requirement is maintained, clarification as to the identities of the different species without reference to the claims is respectfully requested.

In addition, the election of species requirement contains numerous technical and legal errors in the characterizations of Species II-IV. For example, the characterization of Species II in the October 7 Office Communication omits an alcoholate, a thiol, and an AR'_3 group from the possible passivation layers recited in Claim 97. (The alcoholate and thiol passivation layers are presently recited in independent Claim 41.) If the omission was intentional, no reason or explanation has been provided. If this is the case, are claims that read on printing and curing a composition containing passivated semiconductor nanoparticles in which the passivation layer comprises an alcoholate, a thiol, or an AR'_3 group included in constructively elected Group I? If the omission was inadvertent, then clearly a new election of species requirement should be issued, clarifying which passivation layers are included in Species II and, if certain passivation

layers are excluded, explaining why such species are excluded and clarifying to which Species the excluded species belong.

Furthermore, the characterization of Species II in the October 7 Office Communication misstates the language of Claim 144, which recites that the solvent "has a gas-phase dipole moment." If the election of species requirement is maintained, clarification as to the solvents in Species III is respectfully requested.

The requirement to elect a species in the present application is unsupported by plausible reasons and/or examples. No plausible explanation has been given at any time to explain why the elected and withdrawn species are distinct from each other. Only conclusory statements that the species are patentably distinct (see, e.g., the March 12 Office Action, p. 2, l. 8), or that the different species have mutually exclusive characteristics (see, e.g., of the Office Communication dated October 7, 2009; p. 2, l. 26-p. 3, l. 1 of the July 21 Office Action; p. 2, l. 26 – p. 10, l. 2 of the Office Action dated May 30, 2008; etc.) have been offered to support the constructive election of species.

Claims to different species are mutually exclusive if one claim recites limitations disclosed for a first species but not a second, while a second claim recites limitations disclosed only for the second species and not the first. M.P.E.P. § 806.04(f). However, the composition of Species I can include semiconductor nanoparticles passivated with one or more passivation layers. Thus, it is not clear how the composition of Species I, which encompasses semiconductor nanoparticles having one or more passivation layers, has ***mutually exclusive*** characteristics relative to semiconductor nanoparticles of Species II, having a passivation layer comprising an alcohol, a thiolate, an alkyl group, an aryl group, an aralkyl group, hydrogen, or a surfactant. Thus, Species I and Species II as defined above and in the October 7 Office Communication do not have "mutually exclusive characteristics."

Furthermore, the composition of Species I can include a solvent. It is not clear how the solvents of Species III (e.g., being aprotic or apolar, or [presumably] having a gas-phase dipole moment) can be ***exclusive*** of all solvents encompassed by Species I, which clearly can be aprotic

or apolar, or have a gas-phase dipole moment. Thus, Species I and Species III as defined above and in the October 7 Office communication do not have "mutually exclusive characteristics."

In addition, the method of Species I can further include removing the solvent and cleaning with solvent. It is therefore not clear how the method of Species IV (e.g., including removing the solvent and cleaning with solvent) can be ***mutually exclusive*** of the method of Species I, which clearly can include removing the solvent and cleaning with solvent, or vice versa. Thus, Species I and Species IV as defined above and in the October 7 Office Communication do not have "mutually exclusive characteristics."

For similar reasons, Species II (which encompasses compositions that include a solvent) and Species III (which encompasses compositions that include semiconductor nanoparticles passivated with one or more passivation layers) as defined above and in the October 7 Office Communication do not have "mutually exclusive characteristics;" Species II (which encompasses methods that include removing the solvent and cleaning with solvent) and Species IV (which encompasses compositions that include semiconductor nanoparticles passivated with one or more passivation layers) as defined above and in the October 7 Office Communication do not have "mutually exclusive characteristics;" and Species III (which encompasses methods that include removing the solvent and cleaning with solvent) and Species IV (which by the Examiner's own characterization includes a solvent) as defined above and in the October 7 Office Communication do not have "mutually exclusive characteristics."

Applicants reaffirm their traversal of the constructive election of species in the March 12 Office Action, and ***Applicants respectfully request consideration of the July 31, 2008 Petition***.

The Rejection of Claims 41, 43, 44, 46, 56-61, 96, 103-108, 109-117, 124-131, 132, 139-143, 149, 150, 152-154, 165, 166-167, 169-174, 178-184 and 194-197 under 35 U.S.C. § 103(a)

The rejection of Claims 41, 43, 44, 46, 56-61, 96, 103-108, 109-117, 124-131, 132, 139-143, 149, 150, 152-154, 165, 166-167, 169-174, 178-184 and 194-197 under 35 U.S.C. § 103(a)

as being unpatentable in view of Shiho, Jacobson '401, Piwcyzk and Beppu is respectfully traversed.

Independent Claim 41

With respect to the present Claim 41, Shiho discloses silane compositions for preparing semiconductor thin films in solar cells (Abstract). Shiho further discloses several semiconductor thin films that may be formed from the silane compositions disclosed (see paragraph 5 of the Zurcher Declaration). For example, Shiho discloses a series of four components A – D that are the essential components of the compositions disclosed, and may be combined in various ways to form compositions, as described below (see paragraph 6 of the Zurcher Declaration).

Component A is represented by the formula Si_nR_m, with R substituents being selected from hydrogen, alkyl, phenyl or halogens (see paragraph [0040] of Shiho). Component B is at least one silane compound selected from the group consisting of cyclopentasilane, cyclohexasilane and silylcyclopentasilane (see paragraph [0050] of Shiho). Component C is silicon particles (see paragraph [0060] of Shiho), which may have a particle diameter of 0.005 to 1,000 μm (see paragraph [0061] of Shiho), and may be amorphous or crystalline (see paragraph [0063] of Shiho). Component D is at least one boron compound, arsenic compound, phosphorus compound, antimony compound or modified silane compound represented by the formula $Si_aX_bY_c$ (where X is a hydrogen atom and/or halogen atom, Y is a boron atom or phosphorus atom, a is an integer of 3 or more, b is an integer of 1 or more and a or less, and c is an integer of a or more and (2a+b+2) or less, see paragraph [0076] of Shiho; also see paragraph 7 of the Zurcher Declaration).

Shiho is silent with respect to silicon-containing semiconductor nanoparticles having a passivation layer covalently bound thereto selected from the group consisting of an alcohol, an alcoholate, a thiol, a thiolate, an alkyl group, and an aralkyl group (see Claim 41 above; also see paragraph 8 of the Zurcher Declaration). However, silicon-containing semiconductor nanoparticles having a passivation layer covalently bound thereto selected from the group consisting of an alcohol, an alcoholate, a thiol, a thiolate, an alkyl and an aralkyl group (see

Claim 41 above) exhibit superior solubility in certain solvents relative to hydrogen-passivated silicon nanoparticles or unpassivated silicon particles (e.g., those disclosed by Shiho; *vide infra*). Accordingly, the composition recited in the present Claim 41 shows unexpectedly improved printing properties relative to the compositions disclosed by Shiho.

Silicon-containing semiconductor nanoparticles typically exhibit low solubility in conventional organic solvents. As a result, liquid-phase compositions comprising silicon-containing semiconductor nanoparticles often have insufficient mass loading of the silicon-containing semiconductor nanoparticles to make a semiconductor film therefrom (see paragraph 9 of the Zurcher Declaration). For example, unpassivated silicon particles such as those disclosed by Shiho (see paragraph [0061] of Shiho) generally exhibit very low solubility or substantial insolublility in certain organic solvents (e.g., hydrocarbons, arenes and ethers; see paragraph 10 of the Zurcher Declaration).

Data from experiments conducted to test the physical and chemical properties of hydrogen-passivated silicon nanoparticles indicated that compositions comprising hydrogen-passivated silicon nanoparticles and certain organic solvents (e.g., butyl ether, xylene, decalin and others; see page 6 of Exhibit A of the Zurcher Declaration) exhibit very low mass loadings of hydrogen-passivated silicon nanoparticles (< 0.1 %; see page 5 of Exhibit A of the Zurcher Declaration; also see paragraphs 11-13 of the Zurcher Declaration). Hydrogen-passivated silicon nanoparticles were expected to exhibit sufficient solubility in certain organic solvents (e.g., hydrocarbons, arenes and ethers) to enable printing of an ink containing such hydrogen-passivated silicon nanoparticles (see, e.g., paragraph 14 of the Zurcher Declaration). However, the low mass loadings of hydrogen-passivated silicon nanoparticles in compositions comprising the hydrogen-passivated silicon nanoparticles and certain organic solvents indicate that hydrogen-passivated silicon nanoparticles have insufficient solubility in such solvents to enable printing of an ink containing such hydrogen-passivated silicon nanoparticles (see paragraph 14 of the Zurcher Declaration).

Experiments were also conducted to test the physical and chemical properties of compositions containing alkyl-passivated silicon nanoparticles (see paragraphs 15-16 of the Zurcher Declaration). Dodecyl-passivated silicon nanoparticles were chosen as representative alkyl-passivated nanoparticles (see page 3 of Exhibit B of the Zurcher Declaration). The observed physical and chemical properties of dodecyl-passivated silicon nanoparticles are expected to be representative of alkyl-terminated silicon nanoparticles in general (see paragraph 17 of the Zurcher Declaration). Data from experiments conducted to test the physical and chemical properties of compositions containing alkyl-passivated silicon nanoparticles indicated that alkyl-passivated silicon nanoparticles are very soluble in certain organic solvents (e.g., hydrocarbons and ethers; see page 2 of Exhibit B of the Zurcher Declaration; see also paragraph 18 of the Zurcher Declaration). Experiments conducted to quantify the solubility of alkyl-passivated silicon nanoparticles in certain solvents (e.g., hydrocarbons and ethers) indicated that alkyl-passivated nanoparticles possess a solubility of up to 5% in xylene, and greater than 5% in butyl ether (see page 2 of Exhibit C of the Zurcher Declaration; see also paragraphs 19-20 of the Zurcher Declaration). Thus, alkyl-passivated silicon nanoparticles exhibited on the order of two orders of magnitude greater solubility (e.g., 5 % or greater) relative to hydrogen-passivated silicon nanoparticles (e.g., less than 0.1 %; see paragraph 21 of the Zurcher Declaration).

The data, results and observations described above (see also paragraphs 13-14, 18, 20 and 21 of the Zurcher Declaration) and the disclosure of Shiho establish the superior solubility of alkyl-passivated silicon nanoparticles relative to hydrogen-passivated silicon nanoparticles or unpassivated silicon particles (e.g., those disclosed by Shiho; see paragraph 7 of the Zurcher Declaration). Silicon-containing semiconductor nanoparticles having a passivation layer covalently bound thereto selected from the group consisting of an alcohol, an alcoholate, a thiol, a thiolate, and an aralkyl group (see Claim 41 above) are expected to exhibit solubility analogous to that exhibited by alkyl-passivated silicon nanoparticles (see paragraph 23 of the Zurcher Declaration).

The observed insolubility of hydrogen-passivated silicon nanoparticles (< 0.1 %; see page 5 of Exhibit A of the Zurcher Declaration) in certain organic solvents (e.g., butyl ether,

xylene, decalin and others; see page 6 of Exhibit A of the Zurcher Declaration) was unexpected in view of Shiho, who discloses that suitable solvents for compositions comprising (unpassivated) silicon particles include hydrocarbons, arenes and ethers (see paragraph [0103] of Shiho). Therefore, Shiho cannot recognize the superior solubility of silicon-containing semiconductor nanoparticles having a passivation layer covalently bound thereto selected from the group consisting of an alcohol, an alcoholate, a thiol, a thiolate, an alkyl group, and an aralkyl group (see Claim 41 above) relative to unpassivated silicon particles and hydrogen-passivated silicon nanoparticles (*vide supra*; see also paragraphs 22 and 23 of the Zurcher Declaration). Consequently, the results in printing the composition recited in the present Claim 41 are unexpected, and Shiho fails to suggest or render obvious the present Claim 41.

Jacobson '401 fails to remedy the deficiencies of Shiho with respect to the present Claim 41.

Jacobson '401 discloses a method for making electronic, chemical, and mechanical devices by deposition and patterning nanoparticles through printing technology (Abstract). Representative classes of nanoparticles include insulators (e.g., silicon dioxide); semiconductors (e.g., silicon or cadmium selenide); and conductors (e.g., silver) (col. 3, ll. 39-42; see also paragraph 25 of the Zurcher Declaration). Jacobson '401 further discloses that nanoparticles may be passivated at the surface by an organic capping group which surrounds the typically inorganic particle core as a shell. In such circumstances, it is the capping group that largely determines the solubility of the particles, and thus what solvents are appropriate for carrying the particles (col. 4, ll. 47-52).

However, Jacobson '401 fails to disclose any solvents appropriate for solubilizing such inorganic particles having an organic capping group (see paragraph 26 of the Zurcher Declaration). In addition, Jacobson '401 does not explicitly disclose silicon-containing semiconductor nanoparticles having a passivation layer covalently bound thereto selected from the group consisting of an alcohol, an alcoholate, a thiol, a thiolate, an alkyl group, and an

aralkyl group (see Claim 41 above). Furthermore, Jacobson '401 is silent with respect to cyclic Group IVA compounds (see paragraph 27 of the Zurcher Declaration).

The solubility of silicon-containing semiconductor nanoparticles is important for enabling printing of a liquid-phase composition comprising the silicon-containing semiconductor nanoparticles in methods for making patterned semiconductor films. For example, insufficient mass loading of silicon-containing semiconductor nanoparticles in a liquid-phase ink composition comprising the silicon-containing semiconductor nanoparticles may result in a failure to produce a patterned semiconductor film therefrom due to beading and/or uneven spreading of the printed composition. Such beading and/or uneven spreading of the ink composition can also result in unacceptable film morphology and/or pattern uniformity and reproducibility (see paragraph 28 of the Zurcher Declaration).

In general, for many printed electronic devices a semiconductor precursor ink is printed on a non-wetting or non-absorbing substrate. Films formed from such inks on such substrates will exhibit unacceptable pattern variations without a mechanism for controlling pattern uniformity. One example of a mechanism that controls pattern uniformity is including a material in the ink (e.g., nanoparticles) that precipitates from the ink composition before the printed pattern can bead or spread to a significant extent/degree (see paragraph 29 of the Zurcher Declaration). In addition, as the solvent evaporates from a printed ink containing semiconductor nanoparticles, the semiconductor nanoparticles begin to precipitate out of the ink, and may prevent the printed pattern from beading or spreading too unevenly. The greater the mass loading of nanoparticles in the composition, the greater the probability that the nanoparticles will precipitate before significant variations in a printed pattern (e.g., as a result of beading or spreading) can occur (see paragraph 30 of the Zurcher Declaration).

Because of their very low solubility or substantial insolubility in solvents typically used for printable ink compositions, unpassivated silicon nanoparticles or hydrogen-passivated silicon nanoparticles by themselves exhibit insufficient mass loading in such compositions for use in methods of making patterned semiconductor films (see paragraph 31 of the Zurcher Declaration).

The superior solubility of alkyl-passivated silicon nanoparticles (*vide supra*) enables higher mass loading of silicon-containing semiconductor nanoparticles, and accordingly enables the formation of patterned semiconductor films via printing of compositions comprising alkyl-passivated silicon nanoparticles (see paragraph 32 of the Zurcher Declaration).

Neither Shiho nor Jacobson '401 disclose, suggest, or recognize that solubility (and corresponding mass loading) of semiconductor nanoparticles is a result-critical parameter in making patterned semiconductor films by printing compositions comprising semiconductor particles (see paragraph 33 of the Zurcher Declaration). In addition, neither Shiho nor Jacobson '401 disclose, suggest, or recognize that silicon-containing semiconductor nanoparticles having a passivation layer covalently bound thereto selected from the group consisting of an alcohol, an alcoholate, a thiol, a thiolate, an alkyl group, and an aralkyl group (see paragraphs 4, 22 and 23 above) exhibit superior solubility on the order of two orders of magnitude relative to hydrogen-passivated silicon nanoparticles (see paragraph 22 above). Furthermore, neither Shiho nor Jacobson recognize that such superior solubility enables printing of compositions comprising alkyl-passivated silicon nanoparticles in methods for making patterned semiconductor films from such compositions (see paragraph 34 of the Zurcher Declaration).

As a result, no combination of Shiho and Jacobson '401 suggests a method of making a patterned semiconductor film including printing a solution comprising silicon-containing semiconductor nanoparticles having a passivation layer covalently bound thereto selected from the group consisting of an alcohol, an alcoholate, a thiol, a thiolate, an alkyl group, and an aralkyl group, a cyclic Group IVA compound and a solvent in a pattern on a substrate, as recited in the present Claim 41 (see paragraph 35 of the Zurcher Declaration).

Piwcyzk fails to remedy the deficiencies of Shiho and Jacobson '401 with respect to the present Claim 41.

Piwcyzk discloses vacuum deposition methods and masking structures, wherein a coating of a perfluoropolyether compound is applied to surfaces for inhibiting the deposition of a source material by evaporating or sputtering within a vacuum, and for the deposition of such material

onto irregular surfaces, voids, or holes of an object. The coating can be applied by evaporating and then condensing the compound within a vacuum, or it can be applied as a fluid or thixotropic paste through direct contact by means such as a printing process. The coating can further be applied by spraying, or by spinning the surfaces about an axis with the fluid forming a thin coating through the· action of centrifugal force (Abstract).

However, Piwcyzk is silent with respect to silicon-containing semiconductor nanoparticles having a passivation layer covalently bound thereto selected from the group consisting of an alcohol, an alcoholate, a thiol, a thiolate, an alkyl group, and an aralkyl group and a cyclic Group IVA compound, as recited in the present Claim 41. Thus Piwcyzk, like Shiho and Jacobson '401 cannot recognize the unexpectedly superior solubility of silicon-containing semiconductor nanoparticles having a passivation layer covalently bound thereto selected from the group consisting of an alcohol, an alcoholate, a thiol, a thiolate, an alkyl group, and an aralkyl group (*vide supra*), nor that the superior solubility of alkyl-passivated silicon nanoparticles enables higher mass loading of silicon-containing semiconductor nanoparticles, and accordingly enables the formation of patterned semiconductor films via printing of compositions comprising alkyl-passivated silicon nanoparticles (see paragraph 32 of the Zurcher Declaration).

Furthermore, Piwcyzk cannot recognize the myriad problems, issues and/or other factors (as described above and in the Zurcher Declaration) associated with a method of making a patterned semiconductor film including printing a solution comprising silicon-containing semiconductor nanoparticles having a passivation layer covalently bound thereto selected from the group consisting of an alcohol, an alcoholate, a thiol, a thiolate, an alkyl group, and an aralkyl group, a cyclic Group IVA compound and a solvent in a pattern on a substrate, as recited in the present Claim 41 (*vide supra*). As a result, Piwcyzk fails to remedy the deficiencies of Shiho and Jacobson '401 with respect to the present Claim 41.

Beppu fails to remedy the deficiencies of Shiho, Jacobson '401 and Piwcyzk with respect to the present Claim 41.

Beppu discloses a silicon thin film that is formed by coating on a substrate a solution of polysilane represented by the general formula -- $(SiR^1{}_2)_n$ --, where R^1 substituents are selected from the group consisting of hydrogen, an alkyl group having two or more carbon atoms and a β-hydrogen, a phenyl group, and a silyl group, and thermally decomposing the polysilane to deposit silicon (Abstract). Beppu further discloses a silane or germane compound having a one-dimensional chain (linear) or a cyclic structure, in which these compounds may be a copolymer or a mixture (col. 5, ll. 21-24).

Beppu is silent with respect to any semiconductor nanoparticles, much less silicon-containing semiconductor nanoparticles having a passivation layer covalently bound thereto selected from the group consisting of an alcohol, an alcoholate, a thiol, a thiolate, an alkyl group, and an aralkyl group, a cyclic Group IVA compound and a solvent in a pattern on a substrate, as recited in the present Claim 41. Thus, Beppu, like Shiho, Jacobson '401 and Piwcyzk cannot recognize the unexpectedly superior solubility of silicon-containing semiconductor nanoparticles having a passivation layer covalently bound thereto selected from the group consisting of an alcohol, an alcoholate, a thiol, a thiolate, an alkyl group, and an aralkyl group (*vide supra*), nor that the superior solubility of alkyl-passivated silicon nanoparticles enables higher mass loading of silicon-containing semiconductor nanoparticles, and accordingly enables the formation of patterned semiconductor films via printing of compositions comprising alkyl-passivated silicon nanoparticles (see paragraph 32 of the Zurcher Declaration). As a result, Beppu fails to remedy the deficiencies of Shiho, Jacobson '401 and Piwcyzk with respect to the present Claim 41.

No possible combination of Shiho, Jacobson '401, Piwcyzk and Beppu discloses or suggests the unexpected, superior solubility of silicon-containing semiconductor nanoparticles having a passivation layer covalently bound thereto selected from the group consisting of an alcohol, an alcoholate, a thiol, a thiolate, an alkyl group, and an aralkyl group (*vide supra*) in a method of making a patterned semiconductor film including printing a solution comprising silicon-containing semiconductor nanoparticles having a passivation layer covalently bound thereto selected from the group consisting of an alcohol, an alcoholate, a thiol, a thiolate, an alkyl group, and an aralkyl group, a first cyclic Group IVA compound, and a solvent in a pattern on a

substrate, as recited in the present Claim 41. As a result, the present Claim 41 is patentable over Shiho, Jacobson '401, Piwcyzk and Beppu.

Independent Claim 207

With respect to the present Claim 207, one problem associated with making semiconductor films from compositions comprising cyclic Group IVA compounds, including those containing 5 or more silicon atoms in the cyclic ring (hereinafter, "Si_{5+} cyclosilanes") is the stability of Si_{5+} cyclosilanes in those solutions. The stability of compositions containing Si_{5+} cyclosilanes is important for enabling the printability of such compositions in making semiconductor films from such compositions (which may also include passivated semiconductor nanoparticles; see paragraph 37 of the Zurcher Declaration).

Data from experiments conducted to test the stability of Si_{5+} cyclosilanes in various solvents indicated that Si_{5+} cyclosilanes exhibit improved stability in some cycloalkanes (cyclohexane, cycloheptane and cis-decalin) relative to arenes (benzene, toluene, and xylene) and other solvents such as linear alkanes, alcohols, ketones, alkenes, ethers, and fluorinated solvents (see page 3 of Exhibit D of the Zurcher Declaration; see also paragraphs 38-40 of the Zurcher Declaration). The improved stability of Si_{5+} cyclosilanes in some cycloalkane solvents relative to arene solvents was unexpected in view of the published literature reporting mixtures of Si_{5+} cyclosilane(s) in other solvents, typically an arene (namely, toluene; see paragraph 41 of the Zurcher Declaration).

Additional experiments were conducted to test the printability of Si_{5+} cyclosilanes in various solvents, including results of controlled ultraviolet light-initiated polymerization of spincoated Si_{5+} cyclosilanes in a limited number of candidate solvents (see paragraphs 42 and 43 of the Zurcher Declaration). Si_{5+} cyclosilane printability data were collected for a variety of solvents, including cycloalkanes, arenes, a linear alkane, cyclic siloxanes, ethers, and alcohols (see page 2 of Exhibit E of the Zurcher Declaration). Boiling point, viscosity, and Si_{5+} cyclosilane solubility and stability data are reported for the solvents as known or determined. The stability of Si_{5+} cyclosilanes in a solvent was determined by Fourier transform infrared

(FTIR) absorption spectroscopy, by observing the presence or absence of characteristic Si-O bond spectral absorptions in the spectrum. Some samples were heated to 100 °C or 150 °C prior to FTIR absorption spectroscopy. For three solvents (chosen at least in part for reasons relating to the solubility of the Si_{5+} cyclosilane(s) in the solvent or the spin coating properties of the composition), characteristics of a thin film formed from UV polymerization of an ink containing the Si_{5+} cyclosilane(s) in the tested solvent are reported (see paragraph 44 of the Zurcher Declaration).

Cycloalkanes (cyclooctane, *cis*-decalin, and mixed decalins) provide adequate boiling point, viscosity, Si_{5+} cyclosilane solubility and stability, and UV-polymerized thin film properties. Arenes generally exhibited similar viscosity, Si_{5+} cyclosilane solubility and stability results. Cyclic siloxanes generally exhibited similar viscosity, Si_{5+} cyclosilane solubility and stability results (see paragraph 45 of the Zurcher Declaration). Ethers and alcohols generally exhibited relatively poor Si_{5+} cyclosilane solubility and stability results, although the viscosities were generally higher (and thus, more suitable for printing applications). The unacceptable Si_{5+} cyclosilane solubility and stability results observed for ethers and alcohols were unexpected, given that the published literature discloses mixtures of Si_{5+} cyclosilane(s) in such ethers and alcohols (see paragraph 46 of the Zurcher Declaration).

Terpinen-4-ol and terpineol generally exhibited adequate Si_{5+} cyclosilane solubility and stability results relative to cycloalkanes, arenes, and cyclic siloxanes. Terpinen-4-ol and terpineol also generally exhibited higher viscosities relative to cycloalkanes, arenes, and cyclic siloxanes. However, UV-polymerized thin films formed from solutions of Si_{5+} cyclosilanes in terpinen-4-ol and terpineol exhibited some oxidation (i.e., Si-O bonds in the FTIR spectrum and/or oxygen detected in an atomic absorption spectrum of material from the thin films), and thus, were unacceptable for use in Si_{5+} cyclosilane-containing inks for making thin silicon films (see paragraph 47 of the Zurcher Declaration).

UV polymerization trials of 5 wt% solutions of Si_{5+} cyclosilanes in either cyclooctane or o-xylene yielded similar results for both solvents (see page 3 of Exhibit E of the Zurcher

Declaration; see also paragraph 48 of the Zurcher Declaration). However, cycloalkane solvents (cyclooctane and *cis*-decalin) generally solubilized viscous silanes (generally, Si_{5+} cyclosilanes further containing some UV oligomerized and/or polymerized Si_{5+} cyclosilanes), whereas aromatic solvents (o-xylene or methylnaphthalene) generally did not solubilize viscous silanes (see page 4 of Exhibit E of the Zurcher Declaration; see also paragraph 49 of the Zurcher Declaration).

To be suitable for inkjet printing, the solvent for a silane-containing ink should provide the ink with an appropriate viscosity and surface tension (see page 5 of Exhibit E of the Zurcher Declaration). The solvent must also solubilize Si_{5+} cyclosilanes and polymerized silanes to enable formation of silicon films having acceptable physical and electrical properties (see paragraph 50 of the Zurcher Declaration). Terpinen-4-ol, other alcohol and ether solvents were determined to have unacceptable properties for cyclosilane ink printing applications (see page 5 of Exhibit E of the Zurcher Declaration; see also paragraph 51 of the Zurcher Declaration).

Other experiments were conducted to test the suitability of various solvents for inkjet printing of Si_{5+} cyclosilane solutions (containing approximately 80% linear and branched polysilanes and approximately 20% Si_{5+} cyclosilanes; see paragraphs 52 and 53 of the Zurcher Declaration). Candidate solvents (see page 2 of Exhibit F of the Zurcher Declaration) from five representative solvent classes (alkanes, arenes, ethers, halogenated alkanes and alkylsilanes) were purified over activated alumina, and the solubility of silane mixtures was tested for each solvent (see paragraph 54 of the Zurcher Declaration). None of the tested solvents solubilized the silane mixture (see page 2 of Exhibit F of the Zurcher Declaration). However, cycloalkane solvents (e.g., *cis*-decalin, cyclooctane and cyclodecane) were again noted to have superior performance in solubilizing the same mixtures (see page 2 of Exhibit F of the Zurcher Declaration), and generally yielded silicon films having sufficiently good electronic properties to form electrically operational thin film transistors (TFTs), diodes, and/or other electronic structures therefrom (see page 3 of Exhibit F of the Zurcher Declaration; see also paragraph 55 of the Zurcher Declaration).

The data, results and observations described above (*vide supra*; see also paragraphs 40-41, 44-51 and 54-55 of the Zurcher Declaration) demonstrate unexpected and superior Si_{5+} cyclosilane solubility, stability and UV polymerization properties in cycloalkanes relative to other solvents (see paragraph 56 of the Zurcher Declaration). The unexpected and superior Si_{5+} cyclosilane solubility, stability and UV polymerization properties in cycloalkanes relative to other solvents described above (vide supra; see also paragraphs 40-41, 44-51 and 54-55 of the Zurcher Declaration) are not expected to change significantly as a result of the mere presence of passivated semiconductor nanoparticles in a composition containing one or more Si_{5+} cyclosilanes and a cycloalkane solvent (see paragraph 57 of the Zurcher Declaration).

As discussed above, Shiho discloses that suitable solvents for compositions comprising cyclosilanes (and unpassivated silicon particles) include hydrocarbons, arenes and ethers (see paragraph [0103] of Shiho). Shiho is silent with respect to the unexpected and superior Si_{5+} cyclosilane solubility, stability and UV polymerization properties in cycloalkanes relative to other solvents (see paragraph 56 of the Zurcher Declaration). As a result, Shiho cannot suggest the unexpected results afforded by cycloalkane solvents in the present method for method of making a patterned semiconductor film including printing a solution comprising passivated semiconductor nanoparticles, a first cyclic Group IVA compound, and a cycloalkane solvent in a pattern on a substrate, as recited in the present Claim 207.

Jacobson '401 fails to remedy the deficiencies of Shiho with respect to the present Claim 211.

As discussed above, Jacobson '401 discloses a method for making electronic, chemical, and mechanical devices by deposition and patterning nanoparticles through printing technology (Abstract). However, Jacobson '401 is silent with respect to any cyclic Group IVA compounds. Thus, Jacobson '401 cannot suggest the unexpected and superior Si_{5+} cyclosilane solubility, stability and UV polymerization properties in cycloalkanes relative to other solvents (*vide supra*; see also see paragraph 56 of the Zurcher Declaration). Therefore, Jacobson cannot suggest the present method for method of making a patterned semiconductor film including printing a

solution comprising passivated semiconductor nanoparticles, a first cyclic Group IVA compound, and a cycloalkane solvent in a pattern on a substrate, as recited in the present Claim 207. As a result, Jacobson '401 fails to remedy the deficiencies of Shiho with respect to the present Claim 207.

Piwcyzk fails to remedy the deficiencies of Shiho and Jacobson '401 with respect to the present Claim 207.

As discussed above, Piwcyzk discloses vacuum deposition methods and masking structures, wherein a coating of a perfluoropolyether compound is applied to surfaces for inhibiting the deposition of a source material by evaporating or sputtering within a vacuum, and for the deposition of such material onto irregular surfaces, voids, or holes of an object. The coating can be applied by evaporating and then condensing the compound within a vacuum, or it can be applied as a fluid or thixotropic paste through direct contact by means such as a printing process. The coating can further be applied by spraying, or by spinning the surfaces about an axis with the fluid forming a thin coating through the· action of centrifugal force (Abstract).

However, Piwcyzk, like Jacobson '401 is silent with respect to any cyclic Group IVA compounds. Thus, Piwcyzk cannot the suggest unexpected and superior Si_{5+} cyclosilane solubility, stability and UV polymerization properties in cycloalkanes relative to other solvents (*vide supra*; see also see paragraph 56 of the Zurcher Declaration). Therefore, Piwcyzk cannot suggest the present method for method of making a patterned semiconductor film including printing a solution comprising passivated semiconductor nanoparticles, a first cyclic Group IVA compound, and a cycloalkane solvent in a pattern on a substrate, as recited in the present Claim 207. As a result, Piwcyzk fails to remedy the deficiencies of Shiho and Jacobson '401 with respect to the present Claim 207.

Beppu fails to remedy the deficiencies of Shiho, Jacobson '401 and Piwcyzk with respect to the present Claim 207.

As discussed above, Beppu discloses a silicon thin film that is formed by coating on a substrate a solution of polysilane represented by the general formula -- $(SiR^1_2)_n$ --, where R^1 substituents are selected from the group consisting of hydrogen, an alkyl group having two or more carbon atoms and a β-hydrogen, a phenyl group, and a silyl group, and thermally decomposing the polysilane to deposit silicon (Abstract). Beppu further discloses a silane or germane compound having a one-dimensional chain (linear) or a cyclic structure, in which these compounds may be a copolymer or a mixture (col. 5, ll. 21-24).

Beppu discloses that the linear or cyclic silane or germane should be one that is soluble in an organic solvent (col. 5, l. 26). Beppu fails to list suitable solvents for the disclosed silanes and/or germanes. The extent of Beppu's disclosure of solvents is the recitation "organic solvents" (see, e.g., col. 9, l. 18) and solvents disclosed in the Examples (namely, xylene, toluene, and petroleum ether; see, e.g., Examples 1-9, 12, and 14-16 of Beppu), solvents which may not be suitable for compositions comprising cyclic Group IVA compounds (*vide supra*; see also paragraph 49 of the Zurcher Declaration). Furthermore, Beppu fails to affirmatively disclose cycloalkanes solvents. Thus, Beppu cannot disclose the unexpected and superior Si_{5+} cyclosilane solubility, stability and UV polymerization properties in cycloalkanes relative to other solvents (see paragraph 56 of the Zurcher Declaration). As a result, Beppu also cannot suggest the unexpected results afforded by cycloalkane solvents in the present method for method of making a patterned semiconductor film including printing a solution comprising passivated semiconductor nanoparticles, a first cyclic Group IVA compound, and a cycloalkane solvent in a pattern on a substrate, as recited in the present Claim 207. Thus, Beppu fails to remedy the deficiencies of Shiho, Jacobson '401 and Piwcyzk with respect to the present Claim 207.

No possible combination of Shiho, Jacobson '401, Piwcyzk and Beppu suggests the unexpected results afforded by cycloalkane solvents (*vide supra*) in the present method for making a patterned semiconductor film including printing a solution comprising passivated semiconductor nanoparticles, a first cyclic Group IVA compound, and a cycloalkane solvent in a

pattern on a substrate, as recited in the present Claim 207. As a result, the present Claim 207 is patentable over Shiho, Jacobson '401, Piwcyzk and Beppu.

Independent Claim 211

With respect to the present Claim 211, the mass loading of semiconductor nanoparticles in a liquid-phase composition comprising the semiconductor nanoparticles (which may also include cyclic Group IVA compounds) is critical to enable formation of patterned semiconductor films having well-defined features which display controllable, reproducible morphology. Insufficient mass loading of semiconductor nanoparticles may result in beading up, evaporation, or other phenomena which may result in uneven spreading of the printed ink, resulting in unacceptable film morphology and/or pattern uniformity, thickness uniformity and reproducibility (see paragraph 59 of the Zurcher Declaration).

Similarly, the stability of cyclic Group IVA compounds in a liquid-phase composition comprising cyclic Group IVA compounds (which may also include passivated semiconductor nanoparticles) and a solvent is important in making patterned semiconductor films. If the cyclic Group IVA compounds are not stable in the composition, they may precipitate prior to printing, or during a printing process, resulting other phenomena (e.g., clogged inkjet nozzles or uneven mass distribution) which may produce undesirable variations in a patterned semiconductor film (see paragraph 60 of the Zurcher Declaration). Furthermore, to be suitable for printing, the solvent for a solution comprising passivated semiconductor nanoparticles and a cyclic Group IVA compound must (i) provide the ink with an appropriate viscosity and surface tension, (ii) solubilize the Group IVA compound (e.g., a Si_{5+} cyclosilane), and (iii) solubilize the passivated silicon-containing semiconductor nanoparticles to enable formation of patterned semiconductor films having well-defined features (e.g., with pattern dimensions as recited in Claim 211 above) which display controllable, reproducible pattern dimensions and morphology (see paragraph 61 of the Zurcher Declaration).

Shiho discloses forming a silicon film on a substrate by forming a coating film of a silane composition on the substrate by means such as spray coating, roll coating, curtain coating, spin

coating, screen printing, offset printing or ink jet printing (see paragraphs [0106] and [0110] of Shiho). Shiho further discloses that a silicon film, conductive film and insulating film may be formed and patterned before use by a general method such as masking or lithography, or by an inkjet method (see paragraph [0153] of Shiho). Shiho then discloses that the thickness of a silicon ***film*** is preferably 0.005 μm to 20 μm, and more preferably 0.01 to 10 μm (see paragraph [0122] of Shiho, emphasis added; see also paragraph 62 of the Zurcher Declaration).

Shiho is silent with respect to passivated silicon-containing semiconductor nanoparticles as recited in the present Claim 211. Shiho is also silent with respect to one or more ***lines*** having a width of not more than 100 μm, a length of not more than 5000 μm, a thickness of not more than 1000 μm, and an inter-line spacing of not more than 100 μm (see paragraph 58 above; emphasis added). Therefore, Shiho cannot recognize that the mass loading of semiconductor nanoparticles in a liquid-phase composition comprising the semiconductor nanoparticles (which may also include cyclic Group IVA compounds) is critical to enable formation of patterned semiconductor films having well-defined features (e.g., lines having dimensions as recited in the present Claim 211) which display controllable, reproducible pattern dimensions and morphology (see paragraph 64 of the Zurcher Declaration).

Jacobson '401 is silent with respect to cyclic Group IVA compounds. Jacobson '401 is also silent with respect to any dimensions of a printed pattern or features, such as one or more lines having a width of not more than 100 μm, a length of not more than 5000 μm, a thickness of not more than 1000 μm, and an inter-line spacing of not more than 100 μm, as recited in the present Claim 211 (see paragraph 65 of the Zurcher Declaration). Therefore, Jacobson '401 cannot recognize that the stability of compositions containing Si_{5+} cyclosilanes are important for enabling printable compositions containing one or more Si_{5+} cyclosilanes (which may also include passivated silicon-containing semiconductor nanoparticles) for making patterned semiconductor films having well-defined features (e.g., lines having dimensions as recited in the present Claim 211) which display controllable, reproducible pattern dimensions and morphology (see paragraph 66 of the Zurcher Declaration).

The observed solubility of alkyl-passivated silicon-containing semiconductor nanoparticles in an arene solvent and an ether solvent (*vide supra*; see also paragraphs 18 and 20 of the Zurcher Declaration), and the observed stability of Si_{5+} cyclosilanes in some cycloalkane solvents relative to solvents such as arenes, alcohols, ketones, alkenes, ethers, and fluorinated solvents (*vide supra*; see also paragraph 40 of the Zurcher Declaration) are not complementary (see paragraph 67 of the Zurcher Declaration). For example, alkyl-passivated silicon nanoparticles exhibit a solubility of greater than 5% in butyl ether (*vide supra*; see also paragraph 20 of the Zurcher Declaration). However, Si_{5+} cyclosilanes were observed to be unstable or insoluble in butyl ether (cf. page 3 of Exhibit D of the Zurcher Declaration). Similarly, alkyl-passivated silicon nanoparticles exhibited solubility of up to 5% in xylene (*vide supra*; see also paragraph 20 of the Zurcher Declaration). However, in some experiments, Si_{5+} cyclosilanes were observed to be soluble in xylene (see page 2 of Exhibit E of the Zurcher Declaration), while in other experiments, Si_{5+} cyclosilanes were observed to produce a white precipitate in xylene then dissolution over time, suggesting that Si_{5+} cyclosilanes may not be entirely stable in xylene (cf. page 3 of Exhibit D of the Zurcher Declaration).

Since Shiho is silent with respect to passivated silicon-containing semiconductor nanoparticles, Shiho cannot recognize the non-complementary results (see paragraphs 67 and 68 of the Zurcher Declaration) observed in efforts to develop a method of making a patterned semiconductor film including printing a solution comprising passivated semiconductor nanoparticles, a cyclic Group IVA compound and a solvent in a pattern on a substrate, where the pattern comprises one or more lines having a width of not more than 100 μm, a length of not more than 5000 μm, a thickness of not more than 1000 μm, and an inter-line spacing of not more than 100 μm, as recited in the present Claim 211 (see paragraph 69 of the Zurcher Declaration).

Furthermore, since Jacobson '401 is silent with respect to a cyclic Group IVA compound, Jacobson '401 cannot recognize the non-complementary results (see paragraphs 67 and 68 of the Zurcher Declaration) observed in efforts to develop a method of making a patterned semiconductor film including printing a solution comprising passivated semiconductor nanoparticles, a cyclic Group IVA compound and a solvent in a pattern on a substrate, where the

pattern comprises one or more lines having a width of not more than 100 µm, a length of not more than 5000 µm, a thickness of not more than 1000 µm, and an inter-line spacing of not more than 100 µm, as recited in the present Claim 211 (see paragraph 70 of the Zurcher Declaration). As a result, no combination of Shiho and Jacobson '401 suggests or renders obvious the present Claim 211.

Piwcyzk fails to remedy the deficiencies of Shiho and Jacobson '401 with respect to the present Claim 211.

As discussed above, Piwcyzk is silent with respect to any passivated semiconductor nanoparticles. In addition, Piwcyzk is silent with respect to any cyclic Group IVA compounds. As a result, Piwcyzk cannot recognize the non-complementary results (see paragraphs 67 and 68 of the Zurcher Declaration) observed in efforts to develop a method of making a patterned semiconductor film including printing a solution comprising passivated semiconductor nanoparticles, a cyclic Group IVA compound and a solvent in a pattern on a substrate, where the pattern comprises one or more lines having a width of not more than 100 µm, a length of not more than 5000 µm, a thickness of not more than 1000 µm, and an inter-line spacing of not more than 100 µm, as recited in the present Claim 211. As a result, Piwcyzk fails to remedy the deficiencies of Shiho and Jacobson '401 with respect to the present Claim 211.

Beppu fails to remedy the deficiencies of Shiho, Jacobson '401 and Beppu with respect to the present Claim 211.

As discussed above, Beppu is silent with respect to any semiconductor nanoparticles, and fails to disclose suitable solvents for compositions comprising silanes and/or germanes (*vide supra*). In addition, since the extent of Beppu's disclosure of solvents is the recitation "organic solvents" and the solvents disclosed in the Examples (*vide supra*), Beppu cannot recognize the non-complementary results (see paragraphs 67 and 68 of the Zurcher Declaration) observed in efforts to develop a method of making a patterned semiconductor film including printing a solution comprising passivated semiconductor nanoparticles, a cyclic Group IVA compound and a solvent in a pattern on a substrate, where the pattern comprises one or more lines having a

width of not more than 100 μm, a length of not more than 5000 μm, a thickness of not more than 1000 μm, and an inter-line spacing of not more than 100 μm, as recited in the present Claim 211. Thus, Beppu fails to remedy the deficiencies of Shiho, Jacobson '401, and Piwcyzk.

A rationale to support a conclusion that a claim would have been obvious is that all the claimed elements were known in the prior art and one skilled in the art could have combined the elements as claimed by known methods with no change in their respective functions, and the combination would have yielded nothing more than predictable results to one of ordinary skill in the art (See M.P.E.P. 2143.02, citing *KSR International Co. v. Teleflex Inc.*, 127 S. Ct. 1727 at 1741; 167 L. Ed. 2d 705; 82 USPQ2d 1385). However, while obviousness does not require absolute predictability, at least some degree of predictability is required. Evidence showing there was no reasonable expectation of success may support a conclusion of nonobviousness (see M.P.E.P. 2143.02, citing *In re Rinehart*, 531 F.2d 1048, 189 USPQ 143 (CCPA 1976)).

Prior to the work described in the Zurcher Declaration toward developing printable compositions including passivated semiconductor nanoparticles, a cyclic Group IVA compound and a solvent, it was not known whether such compositions could be formed with (i) sufficient mass loading of silicon-containing semiconductor nanoparticles, (ii) sufficient stability and solubility characteristics regarding cyclic Group IVA compounds, and (iii) suitable fluid mechanical properties for printing in a pattern having well-defined features which display controllable, reproducible morphology, such as one or more lines having a width of not more than 100 μm, a length of not more than 5000 μm, a thickness of not more than 1000 μm, and an inter-line spacing of not more than 100 μm, as recited in the present Claim 211 (see paragraph 72 of the Zurcher Declaration).

The evidence presented in the Zurcher Declaration shows that at the time the present invention was made, the results afforded by the present Claim 211 were not predictable, and that one of ordinary skill in the art would not have had a reasonable expectation of success in combining the passivated semiconductor nanoparticles, a cyclic Group IVA compound, and a solvent in a method for making a patterned semiconductor film having well-defined features

which display controllable, reproducible morphology, such as one or more lines having a width of not more than 100 μm, a length of not more than 5000 μm, a thickness of not more than 1000 μm, and an inter-line spacing of not more than 100 μm, as recited in the present Claim 211.

Therefore, no possible combination of Shiho, Jacobson '401, Piwcyzk and Beppu suggests or renders obvious the present method for making a patterned semiconductor film including printing a solution comprising passivated semiconductor nanoparticles, a cyclic Group IVA compound and a solvent in a pattern on a substrate, where the pattern comprises one or more lines having a width of not more than 100 μm, a length of not more than 5000 μm, a thickness of not more than 1000 μm, and an inter-line spacing of not more than 100 μm, as recited in the present Claim 211. As a result, the present Claim 211 is patentable over Shiho, Jacobson '401, Piwcyzk and Beppu.

No possible combination of Shiho, Jacobson '401, Piwcyzk and Beppu discloses or suggests the unexpected, superior solubility of silicon-containing semiconductor nanoparticles having a passivation layer covalently bound thereto selected from the group consisting of an alcohol, an alcoholate, a thiol, a thiolate, an alkyl group, and an aralkyl group (*vide supra*) in a method of making a patterned semiconductor film including printing a solution comprising silicon-containing semiconductor nanoparticles having a passivation layer covalently bound thereto selected from the group consisting of an alcohol, an alcoholate, a thiol, a thiolate, an alkyl group, and an aralkyl group, a first cyclic Group IVA compound, and a solvent in a pattern on a substrate, as recited in the present Claim 41.

In addition, no combination of Shiho, Jacobson '401, Piwcyzk and Beppu discloses or suggests the unexpected results afforded by cycloalkane solvents (*vide supra*) in the present method for making a patterned semiconductor film including printing a solution comprising passivated semiconductor nanoparticles, a first cyclic Group IVA compound, and a cycloalkane solvent in a pattern on a substrate, as recited in the present Claim 207.

Furthermore, no combination of Shiho, Jacobson '401, Piwcyzk and Beppu discloses or suggests the non-complementary results (*vide supra*) observed in efforts to develop a method of

making a patterned semiconductor film including printing a solution comprising passivated semiconductor nanoparticles, a cyclic Group IVA compound and a solvent in a pattern on a substrate, where the pattern comprises one or more lines having a width of not more than 100 μm, a length of not more than 5000 μm, a thickness of not more than 1000 μm, and an inter-line spacing of not more than 100 μm, as recited in the present Claim 211. Furthermore, the evidence presented in the Zurcher Declaration shows that at the time the present invention was made, the results afforded by the present Claim 211 were not predictable, and that one of ordinary skill in the art would not have had a reasonable expectation of success in combining the passivated semiconductor nanoparticles, a cyclic Group IVA compound, and a solvent in a method for making a patterned semiconductor film having well-defined features which display controllable, reproducible morphology, such as one or more lines having a width of not more than 100 μm, a length of not more than 5000 μm, a thickness of not more than 1000 μm, and an inter-line spacing of not more than 100 μm, as recited in the present Claim 211.

As a result, Claims 41, 207 and 211 are patentable over Shiho, Jacobson '401, Piwcyzk and Beppu. Claims 44, 46, 51, 53, 54, 58, 59, 61-65, 100, 101, 103-119, 121-125, 128, 136-147, 149, 150, 152, 155-165, 204, 206 and 231 depend from Claim 41, and thus include all the limitations thereof. Claims 57, 126, 127, 131, 153, 154, 168-173, 175-184, 189, 192-197, 199-201, 205, 208-210, 226, 230, 232 and 234 depend from Claim 207, and thus, include all the limitations thereof. Claims 212-225, 227-229, 233 and 235 depend from Claim 211, and thus include all the limitations thereof. Therefore, the rejection of Claims 41, 43, 44, 46, 56-61, 96, 103-108, 109-117, 124-131, 132, 139-143, 149, 150, 152-154, 165, 166-167, 169-174, 178-184 and 194-197 under 35 U.S.C. § 103(a) as being unpatentable over Shiho, Jacobson '401, Piwcyzk and Beppu is improper, and should be withdrawn.

<u>The Rejection of Claims 51, 53-54, 168 and 204-205 under 35 U.S.C. § 103(a)</u>

The rejection of Claims 51, 53-54, 168 and 204-205 under 35 U.S.C. § 103(a) as being unpatentable in view of Shiho, Jacobson ‘401, Piwcyzk and Beppu, and in further view of Tani is respectfully traversed.

As stated above, no possible combination of Shiho, Jacobson ‘401, Piwcyzk and Beppu suggests or renders obvious the methods for making a patterned semiconductor film as recited in the present Claims 41, 207 and 211. Tani fails to remedy the deficiencies of Shiho, Jacobson ‘401, Piwcyzk and Beppu.

Tani discloses a method for preparing a polymer having linear –Si-O-Si- bonds and –Si-Si-Si- bonds, or polysilane bonds that are greater than trisilane bonds under oxidation with oxygen plasma to form SiO_2 resistant to oxygen dry etching, that is sensitive to far ultraviolet rays and suitable as a single layered resist or an upper resist of a two-layered system (Abstract). Tani further discloses a method for forming a resist pattern using the previously mentioned polymer by selectively irradiated an upper resist layer (3) with pulses of KrF excimer laser rays (4) through a mask carrying a desired pattern (col. 6, ll. 16-20 and Fig. 2C).

However, Tani is silent with respect to any semiconductor nanoparticles. Thus, Tani cannot disclose or suggest the unexpected, superior solubility of silicon-containing semiconductor nanoparticles having a passivation layer covalently bound thereto selected from the group consisting of an alcohol, an alcoholate, a thiol, a thiolate, an alkyl group, and an aralkyl group (*vide supra*) in a method of making a patterned semiconductor film including printing a solution comprising silicon-containing semiconductor nanoparticles having a passivation layer covalently bound thereto selected from the group consisting of an alcohol, an alcoholate, a thiol, a thiolate, an alkyl group, and an aralkyl group, a first cyclic Group IVA compound, and a solvent in a pattern on a substrate, as recited in the present Claim 41.

In addition, Tani is silent with respect to any cyclic Group IVA compounds. Thus, Tani cannot disclose or suggest the unexpected results afforded by cycloalkane solvents (*vide supra*) in the present method for making a patterned semiconductor film including printing a solution

comprising passivated semiconductor nanoparticles, a first cyclic Group IVA compound, and a cycloalkane solvent in a pattern on a substrate, as recited in the present Claim 207.

Furthermore, since Tani is silent with respect to passivated semiconductor nanoparticles and cyclic Group IVA compounds, Tani cannot disclose or suggest the non-complementary results (*vide supra*) observed in efforts to develop a method of making a patterned semiconductor film including printing a solution comprising passivated semiconductor nanoparticles, a cyclic Group IVA compound and a solvent in a pattern on a substrate, where the pattern comprises one or more lines having a width of not more than 100 μm, a length of not more than 5000 μm, a thickness of not more than 1000 μm, and an inter-line spacing of not more than 100 μm, as recited in the present Claim 211. Furthermore, the evidence presented in the Zurcher Declaration shows that at the time the present invention was made, the results afforded by the present Claim 211 were not predictable, and that one of ordinary skill in the art would not have had a reasonable expectation of success in combining passivated semiconductor nanoparticles, a cyclic Group IVA compound, and a solvent in a method for making a patterned semiconductor film having well-defined features which display controllable, reproducible morphology, such as one or more lines having a width of not more than 100 μm, a length of not more than 5000 μm, a thickness of not more than 1000 μm, and an inter-line spacing of not more than 100 μm, as recited in the present Claim 211.

Thus, Tani fails to remedy the deficiencies of Shiho, Jacobson '401, Piwcyzk and Beppu with respect to the methods for making a patterned semiconductor film as recited in the present Claims 41, 207 and 211.

As a result, Claims 41, 207 and 211 are patentable over Shiho, Jacobson '401, Piwcyzk, Beppu and Tani. Claims 51, 53-54 and 204 depend from Claim 41, and thus include all the limitations thereof. Claims 168 and 205 depend from Claim 207, and thus include all the limitations thereof. Therefore, the rejection of Claims 51, 53-54, 168 and 204-205 under 35 U.S.C. § 103(a) as being unpatentable in view of Shiho, Jacobson '401, Piwcyzk and Beppu, and in further view of Tani is improper, and should be withdrawn.

The Rejection of Claims 62-65 and 160-164 under 35 U.S.C. § 103(a)

The rejection of Claims 62-65 and 160-164 under 35 U.S.C. § 103(a) as being unpatentable in view of Shiho, Jacobson '401, Piwcyzk and Beppu, and in further view of Kim is respectfully traversed.

As stated above, no possible combination of Shiho, Jacobson '401, Piwcyzk and Beppu suggests or renders obvious the methods for making a patterned semiconductor film as recited in the present Claims 41, 207 and 211.

Kim fails to remedy the deficiencies of Shiho, Jacobson '401, Piwcyzk and Beppu.

Kim discloses that chemically or biochemically active agents or other species are patterned on a substrate surface by providing a micromold having a contoured surface and forming, on a substrate surface, a chemically or biochemically active agent or fluid precursor of a structure (Abstract). Kim further discloses that the invention provides techniques for derivatizing surfaces, biologically, chemically, or physically, according to predetermined patterns. The derivatized surfaces find a variety of uses in a variety of technical areas, or a structure formed on the surface can be removed from the surface and find utility separate from the surface (col. 4, ll. 36 – 41).

However, Kim is silent with respect to any semiconductor nanoparticles. Thus, Tani cannot disclose or suggest the unexpected, superior solubility of silicon-containing semiconductor nanoparticles having a passivation layer covalently bound thereto selected from the group consisting of an alcohol, an alcoholate, a thiol, a thiolate, an alkyl group, and an aralkyl group (*vide supra*) in a method of making a patterned semiconductor film including printing a solution comprising silicon-containing semiconductor nanoparticles having a passivation layer covalently bound thereto selected from the group consisting of an alcohol, an alcoholate, a thiol, a thiolate, an alkyl group, and an aralkyl group, a first cyclic Group IVA compound, and a solvent in a pattern on a substrate, as recited in the present Claim 41.

In addition, Kim is silent with respect to any cyclic Group IVA compounds. Thus, Tani cannot disclose or suggest the unexpected results afforded by cycloalkane solvents (*vide supra*) in the present method for making a patterned semiconductor film including printing a solution comprising passivated semiconductor nanoparticles, a first cyclic Group IVA compound, and a cycloalkane solvent in a pattern on a substrate, as recited in the present Claim 207.

Furthermore, since Kim is silent with respect to passivated semiconductor nanoparticles and cyclic Group IVA compounds, Kim cannot disclose or suggest the non-complementary results (*vide supra*) observed in efforts to develop a method of making a patterned semiconductor film including printing a solution comprising passivated semiconductor nanoparticles, a cyclic Group IVA compound and a solvent in a pattern on a substrate, where the pattern comprises one or more lines having a width of not more than 100 μm, a length of not more than 5000 μm, a thickness of not more than 1000 μm, and an inter-line spacing of not more than 100 μm, as recited in the present Claim 211. Furthermore, the evidence presented in the Zurcher Declaration shows that at the time the present invention was made, the results afforded by the present Claim 211 were not predictable, and that one of ordinary skill in the art would not have had a reasonable expectation of success in combining the passivated semiconductor nanoparticles, a cyclic Group IVA compound, and a solvent in a method for making a patterned semiconductor film having well-defined features which display controllable, reproducible morphology, such as one or more lines having a width of not more than 100 μm, a length of not more than 5000 μm, a thickness of not more than 1000 μm, and an inter-line spacing of not more than 100 μm, as recited in the present Claim 211.

Thus, Kim fails to remedy the deficiencies of Shiho, Jacobson '401, Piwcyzk and Beppu with respect to the methods for making a patterned semiconductor film as recited in the present Claims 41, 207 and 211.

As a result, Claims 41, 207 and 211 are patentable over Shiho, Jacobson '401, Piwcyzk, Beppu and Kim. Claims 62-65 and 160-164 depend from Claim 41, and thus include all the limitations thereof. Therefore, the rejection of Claims 62-65 and 160-164 under 35 U.S.C. §

103(a) as being unpatentable in view of Shiho, Jacobson '401, Piwcyzk and Beppu, and in further view of Kim is improper, and should be withdrawn.

The Rejection of Claims 100, 101, 135-138, 176, 177, 192 and 193 under 35 U.S.C. § 103(a)

The rejection of Claims 100, 101, 135-138, 176, 177, 192 and 193 under 35 U.S.C. § 103(a) as being unpatentable in view of Shiho, Jacobson '401, Piwcyzk and Beppu, and in further view of Korgel is respectfully traversed.

As stated above, no possible combination of Shiho, Jacobson '401, Piwcyzk and Beppu suggests or renders obvious the methods for making a patterned semiconductor film as recited in the present Claims 41, 207 and 211. Korgel fails to remedy the deficiencies of Shiho, Jacobson '401, Piwcyzk and Beppu.

Korgel discloses a method for production of a robust, chemically stable, crystalline, passivated nanoparticles and composition containing the same, that emits light with high efficiencies and size-tunable and excitation energy tunable color (Abstract). In addition, Korgel discloses a method of forming nanocrystalline or amorphous particles, having an average diameter of between about 1 to about 100 Å from Group IVA metals, by the thermal degradation of a precursor molecule in the presence of molecules that bind to the particle surface, referred to as a capping agent, at high temperatures and elevated pressures (page 1, paragraph [0010] and page 3, paragraph [0032]).

The evidence presented in the Zurcher Declaration shows that at the time the present invention was made, the results afforded by the present Claim 41 were not predictable, and that one of ordinary skill in the art would not have had a reasonable expectation of success in combining the semiconductor nanoparticles having a passivation layer covalently bound thereto selected from the group consisting of an alcohol, an alcoholate, a thiol, a thiolate, an alkyl group, and an aralkyl group, a cyclic Group IVA compound, and a solvent in the present method for making a patterned semiconductor film recited in Claim 41.

In addition, Korgel is silent with respect to any cyclic Group IVA compounds. Thus, Korgel cannot disclose or suggest the unexpected results afforded by cycloalkane solvents (*vide supra*) in the present method for making a patterned semiconductor film including printing a solution comprising passivated semiconductor nanoparticles, a first cyclic Group IVA compound, and a cycloalkane solvent in a pattern on a substrate, as recited in the present Claim 207.

In addition, since Korgel is silent with respect to cyclic Group IVA compounds, Korgel cannot disclose or suggest the non-complementary results (*vide supra*) observed in efforts to develop a method of making a patterned semiconductor film including printing a solution comprising passivated semiconductor nanoparticles, a cyclic Group IVA compound and a solvent in a pattern on a substrate, where the pattern comprises one or more lines having a width of not more than 100 μm, a length of not more than 5000 μm, a thickness of not more than 1000 μm, and an inter-line spacing of not more than 100 μm, as recited in the present Claim 211.

Thus, Korgel fails to remedy the deficiencies of Shiho, Jacobson '401, Piwcyzk and Beppu with respect to the methods for making a patterned semiconductor film as recited in the present Claims 41, 207 and 211.

As a result, Claims 41, 207 and 211 are patentable over Shiho, Jacobson '401, Piwcyzk, Beppu and Korgel. Claims 100, 101, and 136-138 depend from Claim 41, and thus include all the limitations thereof. Claims 176, 177, 192 and 193 depend from Claim 207, and thus include all the limitations thereof. Therefore, the rejection of Claims 100, 101, 135-138, 176, 177, 192 and 193 under 35 U.S.C. § 103(a) as being unpatentable in view of Shiho, Jacobson '401, Piwcyzk and Beppu, and in further view of Korgel is improper, and should be withdrawn.

Conclusions

In view of the above amendments and remarks, all bases for rejection are overcome, and the application is in condition for allowance. Early notice to that effect is earnestly requested.

If it is deemed helpful or beneficial to the efficient prosecution of the present application, the Examiner is invited to contact Applicant's undersigned representative by telephone.

Respectfully submitted,

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